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Report of the
National Science Resources Center
Project to Improve Science Teaching in Elementary Schools
to the
Office of Naval Research
United States Department of Defense

Grant Number N00014-87-G-0276

December 1988

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DISTRIBUTION STATEMENT A

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90 02 00 051

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION Unclassified			1b. RESTRICTIVE MARKINGS		
2a. SECURITY CLASSIFICATION AUTHORITY			3. DISTRIBUTION/AVAILABILITY OF REPORT		
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE			Unlimited; Approved for public release		
4. PERFORMING ORGANIZATION REPORT NUMBER(S)			5. MONITORING ORGANIZATION REPORT NUMBER(S)		
6a. NAME OF PERFORMING ORGANIZATION National Science Resources Center		6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION Office of Naval Research		
6c. ADDRESS (City, State, and ZIP Code) Washington, DC 20560			7b. ADDRESS (City, State, and ZIP Code) Arlington, VA 22217-5000		
8a. NAME OF FUNDING/SPONSORING ORGANIZATION Deputy Director, Defense Research and Engineering (R&AT/RLM)		8b. OFFICE SYMBOL (If applicable) DDDRE (R&AT/RLM)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER N00014-87-G-0276		
8c. ADDRESS (City, State, and ZIP Code) Washington, DC 20301-3080			10. SOURCE OF FUNDING NUMBERS		
			PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.
			WORK UNIT ACCESSION NO.		
11. TITLE (Include Security Classification) Report of the National Science Resources Center Project to Improve Science Teaching in Elementary Schools					
12. PERSONAL AUTHOR(S) Shuler, Sally G.					
13a. TYPE OF REPORT		13b. TIME COVERED FROM _____ TO _____		14. DATE OF REPORT (Year, Month, Day) 1988 December	
15. PAGE COUNT 13					
16. SUPPLEMENTARY NOTATION					
17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)		
FIELD	GROUP	SUB-GROUP	*Education, *Science, *Schools, *Elementary Education		
19. ABSTRACT (Continue on reverse if necessary and identify by block number) This report reviews the goals and achievements of the special Secretary of Defense project conducted by the National Science Resources Center (NSRC) to review programs sponsored by DoD that support the improvement of precollege science and mathematics education, establish interactive links between these programs and the NSRC, and initiate activities to enhance the quality of DoD programs in these areas. Additional details of the products of the project are found in the appendices of this report: School Systems with Exemplary Elementary Science Programs; Elementary Science Newtwork; Elementary Science Information Database; Science for Children, an Agenda for Action; Science for Children: Resources for Teachers.					
20. DISTRIBUTION/AVAILABILITY OF ABSTRACT <input checked="" type="checkbox"/> UNCLASSIFIED/UNLIMITED <input type="checkbox"/> SAME AS RPT. <input type="checkbox"/> DTIC USERS			21. ABSTRACT SECURITY CLASSIFICATION		
22a. NAME OF RESPONSIBLE INDIVIDUAL Jeanne D. Carney			22b. TELEPHONE (Include Area Code) (202) 694-0205		22c. OFFICE SYMBOL DDDRE (R&AT/RLM)

NATIONAL SCIENCE RESOURCES CENTER

PROJECT TO IMPROVE SCIENCE TEACHING IN ELEMENTARY SCHOOLS

Introduction

In response to the national need to improve the teaching of science and mathematics in our nation's schools, the Department of Defense (DOD) has been providing support for a special Secretary of Defense (SECDEF) project conducted by the National Science Resources Center (NSRC). During the past two years, the project has reviewed the programs currently sponsored by the Department of Defense that support the improvement of precollege science and mathematics education, established interactive links between these DOD programs and the NSRC, and initiated activities to enhance the quality of DOD programs in these areas.

During the first year, the NSRC studied the activities of DOD precollege science and mathematics educational programs, developed links between these programs and the NSRC, and recommended program areas where DOD and the NSRC could work together as partners in improving precollege science and mathematics education. The NSRC submitted a report of its findings and recommendations to DOD in October 1987. A primary recommendation of this report addressed the need to expand the focus of DOD-sponsored science and mathematics education programs to include more emphasis at the elementary school level, in order to prepare and motivate children to take more science and math courses in secondary school.

This SECDEF study led the NSRC to design a four-year project to improve the teaching of science in elementary schools throughout the nation and overseas. The goals of this project are to develop and disseminate a set of "hands-on" resource units on important topics in science and technology for grades 1-6, and to provide a program of leadership development and other outreach activities to help school systems improve their elementary science programs. The project will build on and extend the NSRC's current links with Department of Defense Dependents Schools (DODDS) and other school systems serving children of military personnel as well as other DOD-sponsored programs supporting the improvement of precollege science and mathematics education.

During FY 1988, the NSRC began work on this project by: 1) identifying school systems with exemplary elementary science programs that could serve as models for other school systems; 2) forming a network of institutions to facilitate the sharing of ideas and resources for improving science teaching in elementary schools; 3) developing a resource collection and information database of elementary science teaching materials to serve as a resource for school

systems; 4) disseminating information about these resources to teachers and school system administrators; 5) providing assistance to institutions that are planning elementary science improvement efforts; and 6) initiating the development of a set of elementary science teaching units for use in grades 1-6.

These project activities have been conducted by the National Science Resources Center, established in 1985 as a joint undertaking of the National Academy of Sciences and the Smithsonian Institution. The NSRC's mission is to contribute to the improvement of science and mathematics teaching in the nation's schools by developing and maintaining a science and mathematics curriculum resource center and information database, developing and disseminating resource materials for science and mathematics teachers, and sponsoring a program of outreach and leadership development activities.

Project Rationale

In 1983, the National Science Board's Commission on Precollege Education reached a sobering conclusion: "The Nation that dramatically and boldly led the world into the age of technology is failing to provide its own children with the intellectual tools needed for the twenty-first century." The report warned that many young people in school today will be scientifically and technologically illiterate unless a determined effort is made to improve the teaching of science and mathematics.

Since then, numerous national reports have bemoaned the lack of qualified graduates to fill math, science, and engineering jobs. In international competitions, even the best American students score below students of other industrialized nations. In spite of efforts to attract women and minorities to careers in science and technology, their representation in these fields is small and declining. Science literacy is at a low level in our culture, and our schools have failed to keep up with the needs of our high-technology society.

Children in the United States are receiving insufficient training in science and mathematics to meet future economic, technological, and military demands. Business and military leaders are spending millions of dollars on remedial education and training programs. In a speech at the National Academy of Sciences' Convocation on Science and Mathematics in the Schools, former Secretary of Defense Caspar Weinberger warned that "Unless we begin now to motivate and equip them to pursue scientific and technological careers, the shortages will persist. That national lesson Sputnik taught us in 1957 should still serve us." He stressed the need for youngsters to be exposed as early as possible to science, math, and technology.

In response to the need to improve the teaching of science and mathematics in our nation's schools, the Department of Defense (DOD) has been providing support for a special Secretary of Defense (SECDEF) project directed by the National Science Resources Center.



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Project Accomplishments

During the past two years, the NSRC has (1) reviewed the programs currently sponsored by DOD that support the improvement of precollege science and mathematics education; (2) established interactive links between these programs and the NSRC; and (3) organized activities to enhance the quality of the DOD precollege science and mathematics programs.

During FY 1987, the NSRC interviewed representatives and reviewed the materials produced by the following DOD programs that support the improvement of precollege science and mathematics education:

- o DOD Apprenticeship Programs
- o DOD Teacher Internship Programs
- o DOD Partnership Programs
- o DOD Dependents Schools
- o U.S. Army National Science Center for Communications and Electronics (Fort Gordon, Georgia)
- o The "Second Career" joint initiative by the Secretary of Defense and the Secretary of Education to encourage retired military personnel to become teachers and school administrators

In carrying out this study, the NSRC exchanged materials and established links with personnel coordinating the above DOD programs. The DOD personnel interviewed were provided with information about the National Science Resources Center, and invited to identify ways in which the NSRC might assist them in achieving program goals. The NSRC submitted a report of its findings and recommendations to DOD in October 1987. This report recommended that the Department of Defense expand the focus of its science and mathematics education programs to include more emphasis at the elementary school level, in order to prepare and motivate children to take more science and math courses in secondary school.

This SECDEF study led the NSRC to design a four-year program of activities to improve the teaching of science in elementary schools throughout the nation and overseas. The project will develop and disseminate quality science resource materials and organize a program of leadership development and other outreach activities to help school systems to improve their elementary science programs. The project will build on and extend the NSRC's current links with DODDS and other schools serving children of military personnel, as well as other DOD-sponsored programs supporting the improvement of precollege science and mathematics education.

During FY 1988, the NSRC initiated activities to improve science teaching in elementary schools and accomplished the following objectives:

1. Identified School Systems with Exemplary Elementary Science Programs to Serve as Models for Other School Systems

The NSRC identified school systems with exemplary elementary school science programs to serve as sources of expertise, curriculum resources, and practical experience for other school systems that are working to incorporate hands-on

science into their elementary school curricula. The school systems with exemplary elementary science programs that have been identified by the NSRC are listed in Appendix A. The criteria used to identify these exemplary elementary science programs are based on those developed by Project Synthesis (Harms and Yager, 1981) and are summarized below:

- o The development of the young child's intellect is the major focus of elementary science instruction, rather than the development of detailed concepts in preparation for secondary school science.
- o The science program excites children's curiosity, builds their interest in the world, and provides them with opportunities to practice the methods of science.
- o Science process skills are developed through experiences with phenomena that are observed, described, compared, and analyzed.
- o The elementary science curriculum emphasizes the development of problem-solving skills; addresses important issues involving science and society; includes the study of a variety of topics in the life, earth, and physical sciences; and develops an awareness of career opportunities in science.
- o The elementary science program provides frequent opportunities for students to discuss their observations and to debate the alternative solutions to problems.
- o All children have equal access to science instructional resources from teachers who have sufficient experience and knowledge to be confident about teaching science.
- o Teachers exhibit an understanding of the stages of cognitive development in children and demonstrate the ability to use teaching strategies that are appropriate to these stages.
- o School district policy provides for an adequate amount of time dedicated to the teaching of science in the elementary school curriculum.
- o The school district provides teachers with sufficient science apparatus to enable each child to work with concrete materials, and has developed an effective logistical system for supplying science apparatus and materials to teachers.

Throughout the project, the NSRC will continue to use the above criteria to identify additional school districts with exemplary elementary science programs.

2. Created a Network of Institutions to Share Ideas and Resources for Improving Science Teaching in Elementary Schools

The National Science Resources Center has established an active, nationwide NSRC Elementary Science Network. This network is composed of school districts with exemplary elementary science programs, school districts that are just beginning to build hands-on elementary science programs, and scientists and science educators who are involved in activities to support and improve the teaching of science in elementary schools. The primary function of this network is to share and disseminate information about elementary science resource materials and elementary science program improvement strategies.

The NSRC has developed a computer database of approximately 5,000 superintendents, science supervisors, teachers, scientists, science museum educators, and officials from professional organizations and associations who are currently participating in the NSRC Elementary Science Network. Additional school systems, scientists, and science educators will be added to the NSRC Network as they are referred to us by Network members, or respond to publicity about the project. The names that are currently included in the NSRC Elementary Science Network are listed in Appendix B.

3. Assessed the Needs of School Systems and Identified Strategies for the Improvement of Science Teaching in the Nation's Schools

To assess the needs of school systems and to facilitate communication among the members of the network described above, the National Science Resources Center staff has held ongoing discussions with scientists, teachers, school system science supervisors, science museum educators, and representatives from scientific and professional organizations from throughout the country to identify strategies for the improvement of science teaching in the nation's elementary schools. Members of the NSRC Network have helped the NSRC to identify the elementary science materials that have been successfully used by large numbers of elementary school teachers, designs for effective teacher inservice education programs, and the logistical systems needed to supply elementary school teachers with science apparatus and materials.

During the past year, NSRC staff members have met with science supervisors and school administrators from a number of large school systems, including DODDS-Germany, Milwaukee City Public Schools, Baltimore City Public Schools, and Chicago City Schools. These discussions have provided the NSRC with a clearer understanding of the special needs of DODDS schools, as well as the special problems of large urban school systems. As a result of these contacts, the staff from these school systems have begun to communicate frequently with the NSRC staff and with other members of the NSRC Network to obtain suggestions on improving their elementary science programs.

4. Established a Collection and Information Database of Elementary Science Teaching Materials to Serve as a Resource for Members of the NSRC Network

During the past year, the NSRC staff has developed a collection of elementary science teaching resource materials and has created an elementary science information database. The resource materials in the collection include the following:

- o Elementary science resource materials produced by federally-supported science curriculum development projects.
- o Elementary science resource materials developed in recent years by science museums and school systems, including local adaptations of materials produced by the major national elementary science curriculum projects.
- o Elementary science materials developed in other countries, including Great Britain, Australia, and Canada.

The NSRC now has approximately 3,000 volumes in the NSRC elementary science collection, housed in the NSRC library in the Smithsonian Arts & Industries Building. Hundreds of commercial publishers were contacted to obtain these materials. Some materials which were produced for local or regional use, and were therefore not available from commercial publishers, were acquired directly from the local school systems, science museums, university teaching centers, and other organizations that produced them. Some of the materials produced by federally-supported elementary science curriculum projects that are now out-of-print were donated to the NSRC by the members of the NSRC Network. In addition, the NSRC obtained Science Helper K-8, an archival CD-ROM videodisc produced at the University of Florida that contains many out-of-print elementary science materials.

After creating this elementary science teaching resource collection, the NSRC developed an elementary science computer information database. This database includes brief annotations, as well as bibliographic information about the materials in the elementary science resource collection. As new resources become available, they will be added to the NSRC collection and database. A print-out of some of the entries in the NSRC elementary science information database is included as Appendix C.

5. Disseminated Information to Assist School Systems and Other Educational Institutions Planning Elementary Science Program Improvement Efforts

The dissemination activities of the project have been targeted at promoting public awareness of the need to improve the teaching of science in elementary schools. The NSRC has provided school systems and other educational institutions with information about exemplary elementary science programs that can be used as models, and has facilitated the sharing of ideas and resources to improve elementary school science. Dissemination activities have included NSRC-sponsored conferences and workshops, presentations at meetings of professional

associations and organizations, the distribution of resource materials, the publication of the NSRC Newsletter, and direct assistance provided to school systems seeking help to improve their elementary science programs.

The National Conference on the Teaching of Science in Elementary Schools, held at the National Academy of Sciences and the Smithsonian Institution in 1986, brought together one hundred scientists and science educators. Participants included Dale Hunter, Chief, Curriculum Branch, Education Division of DOD Dependents Schools, and Barbara Clark, Science Coordinator, Curriculum Branch, Education Division of DOD Dependents Schools. During three days of discussions, the conference participants reviewed the current state of science teaching in the nation's elementary schools, heard reports from science supervisors and school systems that have implemented exemplary elementary science programs, and made recommendations to guide future efforts.

The recommendations that emerged from this conference were published in the form of a brochure "Science for Children: An Agenda for Action." In the spring of 1988, these recommendations were disseminated to the 16,000 superintendents of schools, the 1,000 members of the National Science Supervisors Association, the 88 members of the Council of State Science Supervisors, and the 5,000 members of the NSRC Elementary Science Network, which includes all DODDS schools. A copy of the "Agenda for Action" brochure is included in Appendix D.

The NSRC resource collection and information database of elementary science teaching materials have been made available to school systems and regional science education centers that are planning elementary science program improvement efforts. The resource collection is also used by participants in NSRC workshops and conferences.

To provide school systems across the nation with access to the NSRC information database, the NSRC joined PSI-NET, a nationwide computer telecommunications network linking the science supervisors in the state departments of education. PSI-NET is sponsored by the Council of State Science Supervisors, with support from IBM and the National Science Foundation. In addition to the state departments of education, PSI-NET includes a number of national organizations that are actively involved in science and mathematics education. Functioning as an electronic bulletin board and conference center, PSI-NET is designed to improve direct communications among science and mathematics educators.

The NSRC has recently completed the preparation of an annotated guide of elementary science teaching resources, Science for Children: Resources for Teachers (Appendix E). This book describes materials that are currently available for hands-on elementary and middle school science teaching. This resource guide was published by the National Academy Press this fall and disseminated to the nation's 16,000 superintendents of schools. Copies of the guide were also sent to DODDS science supervisors and to all DODDS elementary schools. In addition to distributing these complimentary copies, the NSRC will also disseminating the guide though the National Academy Press. Support for the preparation and publication of the guide was provided by the Smithsonian Institution.

In addition to the publication of this resource guide, the NSRC has begun to publish a newsletter to communicate with the members of the growing NSRC network of teachers, scientists, science educators, and school administrators. Approximately 21,000 copies of the first issue of the NSRC Newsletter were distributed to the nation's superintendents of schools, to the DODDS schools, and to other members of the NSRC Network. A second issue will be published this winter. A copy of the first NSRC Newsletter is included in Appendix F.

NSRC staff members have attended the annual meetings of many educational organizations to give presentations and disseminate information about improving the teaching of science in elementary schools. Participants at these meetings were invited to join the NSRC Elementary Science Network by completing a form and returning it to the NSRC. NSRC presentations were made at the annual meeting of the AAAS National Forum for School Science (November 14-15, 1986, and November 20-21, 1987), the Wisconsin Society of Science Teachers (February 9, 1988), the Association for Supervision and Curriculum Development (March 21-24, 1987, and March 12-15, 1988), the National Association of State Boards of Education (March 21, 1988), the National Science Teachers Association (April 26-29, 1987, and April 7-10, 1988), and the National Science Supervisors Association (April 1987 and April 1988). A copy of the materials distributed at these meeting is included in Appendix G.

To share alternative models and methods for supporting teacher network projects, and ways to build, operate, evaluate, and sustain collaborative teacher empowerment efforts, NSRC staff members participated in two workshops sponsored by the Teacher Networks Group (March 1988 and June 1988). At these meeting, participants from government agencies and private foundations discussed different approaches to technical assistance that were being used by a number of projects to improve science and math education.

6. Initiated the Development of NSRC Elementary Science Teaching Units for Grades 1-6

During FY 1988, the NSRC began development of the first set of NSRC elementary science teaching units for grades 1-6. These units actively involve elementary school children in scientific investigations and problem-solving activities. The materials make hands-on science more manageable for elementary school teachers by linking science to the broader elementary school curriculum of reading, writing, mathematics, social studies, and art. The NSRC elementary science units are being developed and field-tested with the assistance of a group of school systems that are participating in the NSRC Network.

Each of the NSRC science units provide opportunities for children to investigate an important concept in science and technology. Some examples of the kinds of science materials that are under development include:

Chemistry of Liquids. In this unit, children investigate some of the chemical properties of liquids and learn how various tests and indicators can be used to differentiate between liquids that appear similar. Students investigate the differences between acids and bases by using indicators made from natural substances such as grape juice

and cabbage leaves. They also compare the solubility of substances in different liquids and use paper chromatography to separate the components of ink and dye mixtures. In addition, students study the practical uses of various mixtures, emulsions, solutions, and suspensions by testing some common non-toxic products found in the home.

Plant Growth and Development. Fast-growing Brassica campestris plants, a variant of wild mustard, have been developed by Paul Williams, a plant pathologist at the University of Wisconsin at Madison. These small plants thrive under fluorescent lighting, can withstand crowded growing conditions, and have an accelerated life cycle of less than 40 days. These characteristics make the Brassica "fast plants" an ideal resource on which to base a unit to enable young children to investigate seed germination, plant growth and development, and pollination.

Electrical Circuits. Hands-on experiences with simple electrical circuits are especially important today, because many children are intimidated by the electronic "black boxes" found in many modern appliances and toys, and have never had an opportunity to become familiar with basic electrical phenomena. Beginning with the challenge to light a bulb, given only a battery, bulb, and wire, children progress through a series of challenges that reveal to them how electricity behaves. What kinds of materials will conduct electricity? Are all liquids conductors? These kinds of questions lead students to explore electrical resistance, parallel and series circuits, and some of the practical applications of electricity.

Microscopes and Microbes. Children heighten their powers of observation by using scientific tools such as hand lenses and simple microscopes to explore the microworld that is all around us. As they make a visual safari through a drop of pond water, children become acquainted with the amazing "wee beasties" that share our world but are often unseen. Bread, cheese, and yogurt provide children with food for thought, as they explore some of the practical applications of microbiology. The unit makes use of simple and inexpensive microscopes to help children recognize that the miniature residents of the microworld have an enormous impact on their daily lives.

The trial-teaching of these units is now underway in classrooms in the Capitol Hill Cluster Schools, a group of inner city schools in Washington, DC. The field-testing of this first set of elementary science units is planned for the spring of 1989.

Project Evaluation

To evaluate the NSRC Project to Improve Science Teaching in Elementary Schools, information was collected from telephone interviews with participants representing the different types of educational institutions in the NSRC Elementary Science Network. Through these interviews, the NSRC learned that the use of a variety of dissemination processes were necessary to maintain the active participation of Network members. Direct communication by telephone and face-to-face encounters at NSRC conferences and workshops promoted the most active sharing of ideas and resources, but the number of institutions that the NSRC was able to involve in this way was limited.

Although printed materials were not as effective as direct communication, the members of the network indicated that the NSRC Newsletter provided an excellent method to involve all members of the network in the process of sharing ideas and resources. Of the 21,000 copies of the first newsletter distributed to superintendents, science supervisors, and other interested individuals, approximately 5 percent (1,100) have returned the attached form to indicate that they wanted to join the NSRC Elementary Science Network.

Approximately ten percent (112) of the individuals attending NSRC presentations at national meetings and conferences returned the NSRC response form that was enclosed with the NSRC publicity packet. The NSRC has also received more than 200 inquiries by telephone or letter about the elementary science activities of the Center. These inquiries have been prompted by the NSRC Newsletter, NSRC publicity packet, network referrals, and publicity about the NSRC. The majority of these inquiries have come from school administrators, science supervisors, and university scientists.

The NSRC has maintained records throughout the project to document the extent of use of the information and services provided by the NSRC project to improve science teaching in elementary schools. These records include the numbers and kinds of educational institutions that have obtained assistance from the project. Data have also been assembled on the number and nature of the participants in the Elementary Science Network, and on the size and nature of the audiences that attended the presentations made by project staff at national meetings and conferences. The number and demographic distribution of requests for information received by the project have been analyzed to identify states and user populations that may require special attention in the future.

Because the NSRC has been disseminating information about a broad range of elementary science programs and resource materials to many different types of educational institutions, it has not been possible to make a quantitative assessment of the gains in student achievement that might have occurred as a result of the project's activities. However, information from the NSRC Elementary Science Network participants is being solicited this fall to help assess the impact of the assistance provided by the project on the quality and effectiveness of the elementary programs operated by participants in the NSRC Network. This assessment is being made by means of a response form that is being distributed to 16,000 superintendents of schools, 1,500 science supervisors, and other participants in the NSRC Network.

Conclusion

The NSRC's project with the Department of Defense to improve science teaching in elementary schools has brought about some important long-term benefits. It has:

- o Created an active network of people who are committed to improving the teaching of science in elementary schools.
- o Stimulated local efforts to improve the teaching of science in the nation's elementary schools.
- o Increased the involvement of the best minds in the scientific and educational communities in the task of improving elementary science teaching.
- o Enabled teachers and schools to improve the scientific literacy of young children so that they will be able to participate effectively as citizens in a technological society.

The National Science Resources Center has effectively involved scientists, teachers, and science educators in its project to improve the teaching of science in elementary schools. Each of these groups have made a unique contribution to the project: scientists for their knowledge of science, technical expertise, and creativity; teachers for their understanding of the issues and needs of schools; and science educators for their knowledge of pedagogy and the cognitive development of children.

The NSRC plans to build on the successful activities of FY 1988 and continue to work to improve elementary school science teaching in FY 1989. In future years, the NSRC plans to expand its focus to include other areas of the precollege science and mathematics curriculum.

Appendices

- A. School Systems with Exemplary Elementary Science Programs
- B. Elementary Science Network
- C. Elementary Science Information Database
- D. Brochure: Science for Children: An Agenda for Action
- E. Science for Children: Resources for Teachers
- F. NSRC Newsletter
- G. NSRC Publicity Packet